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Life & Efficiency Tests Of Tungsten Lamps

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LIFE AND EFFICIENCY TESTS OF TUNGSTEN LAMPS

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June 1, 1909

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

NAPOLEON HIRAM BOYNTON and HARRY STEPHEN LOFQUIST

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IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF Bachelor of Science in Electrical Engineering

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LIFE AND EFFICIENCY TESTS OF TUNGSTEN LAMPS.

The purpose of this thesis was to compare the several varieties of twenty-five watt multiple tungsten lamps as to life and efficiency, as fairly and completely as was possible in laboratory tests.

Lamps.

The lamps tested were of three kinds. These were selected as they represent all the principal methods of manufacture of tungsten filaments which are on the market. The three kinds were the Just lamp, the Kuzel lamp, and the Columbia lamp. All the lamps used were rated as twenty-five watts on one hundred and ten volts.

The Just lamp is a lamp of German manufacture though advertised extensively in this country. The filaments for these lamps are made by a process known as the Coating process, which was first protected by the British patent of Drs. Just and Hanaman. In this process, ordinary carbon filaments (two hundredths to six hundredths millimeters in diameter) are raised to a bright red heat by means of an electric current in an atmosphere of volatile tungsten compounds in the presence of hydrogen. The heat of the filament causes the hydrogen to reduce the metallic

JUST LAMP. KUZEL LAMP. COLUMBIA LAMP.

compounds, depositing the metal homogeneously on the carbon filament. After the coating the carbon and tungsten are made to combine by heating in hydrogen, producing a tubular filament. The carbon is removed by heating in steam and hydrogen, leaving the pure tungsten. The singular feature in the appearance of these lamps is the spring supported filament spire. The filaments are mounted tightly over the metal spiders at the end of the spire.

The Kuzel lamp is another German lamp well known in this country. The filament of this lamp is made by the Colloidal process of Dr. Kuzel. In this process an arc is formed between tungsten electrodes under water or possibly some other liquid and a colloidal solution is formed which is brought to the proper consistency and squirted through dies. In this method there is the advantage of the absence of all organic matter. The filaments are mounted on glass spires in a helical arrangement as is shown in the photograph.

The Columbia lamps were made by the Columbia Incandescent Lamp Company of St. Louis, Missouri, and are representative of all the principle American lamps as the filaments of most American lamps are made by the same Paste process. Finely divided tungsten metal is mixed in a suitable binder such as gums, dextrine, and other similar substances, and the mass reduced to the consistency of putty. This is squirted through a very fine orifice in diamond, resulting in a moist thread.

This thread is then heated in an atmosphere of steam and hydrogen to remove the carbon in the binding material. This leaves a filament of almost pure tungsten. These filaments are loosely mounted on a glass spire and supported only at the ends.

The lamps, fifty of each type, which were placed on test were selected from one hundred lamps purchased on the market. They were selected for uniformity of candle power, vacuum, and filament. The vacuum was tested by the ordinary flashing method, and the filaments by impressing low voltage on the lamps and inspecting for dark or light spots and for kinks.

Tests.

All candle power measurements were taken on a three meter Bunsen Photometer fitted with a Leeson Star Screen. The standard lamp used was calibrated at twenty candle power by the Electrical Testing Laboratories of New York. A Kuzel lamp was selected and burned for one hundred hours, then calibrated, and used as a sub-standard in the measurements. The measurements of current and voltage were taken on Weston Laboratory Standard Instruments.

Tests were run under two conditions denoted by "A" and "B". Under condition A the lamps were given a severe trial. They were burned vertically on sixty cycle alternating current from the line voltage and were supported in racks which received all the vibration of the building. Under condition B the lamps were burned vertically on direct current and were mounted in a

rack which was supported on springs. The lamps were arranged alternately, (Just, Kuzel, Columbia) so as to give as nearly as possible the same conditions to each set of lamps. Each lamp occupied the same socket throughout the test. The lamps were burned nearly continuously with stops only long enough to measure candle power and current consumption at frequent intervals. These intervals were about fifty hours for the first several readings and about one hundred hours for the other readings. Crates were provided for carrying seventy-five lamps at a time to the photometer. The photometer was read by the same person throughout the complete test so as to eliminate personal error.

As above mentioned condition A was very severe. The vibration of the laboratory building is always excessive because of the power plant and laboratory machines. The line voltage varies widely and rapidly. In condition B the voltage was very closely regulated so as to be almost constant. Storage batteries were floated across the line and charged through a lamp bank. The rate of charge could be regulated by the number of lamps in the bank. A large rheostat was provided at the test rack in order to regulate the impressed voltage more closely.

Discussion of Curves and Conclusions.

On the following pages of this thesis will be found curves showing the relation between average values of

(a) Watts per candle power and hours of life,

(b) Candle power and hours of life,

(c) Current consumption and hours of life, for each set of twenty-five lamps. There will also be found six sheets with curves showing the variation of candle power with life for each lamp.

It will be noticed that the life of each type of lamp is greatly reduced under condition A. While this test was thought at first to represent common working conditions, it was afterwards decided that incandescent lamps would seldom be subject to such severe usage as they received on this test. Harsher usage would certainly not be expected in stationary illumination. It was noticed that the filaments of the Just lamps vibrated more than either of the other types. This was probably due in part to resonance between the vibration of the building and the filament. The shortness of the life of these lamps under this condition and the greater life under condition B is explained by the above fact. It can hardly be concluded from this test that Just lamps may not be expected to burn for more than two hundred hours on alternating current where vibration is present. The fact that about fifty per cent of the Columbia lamps burned one thousand hours under condition A indicates that these lamps can be burned satisfactorily under similar conditions. Neither of the German makes can be recommended for this service.

The following discussion applies chiefly to condition B, as it was thought to afford a more favorable basis for com-

parison.

From the tests the one important conclusion is that the life and efficiency of twenty-five watt tungsten lamps is much greater than any other commercial incandescent multiple lamp of the same candle power. Their life under ordinary care will be at least eight hundred hours which is all that is claimed for them by the manufacturers. The efficiency, while decreasing slightly with life, is for the most part better than one and four-tenths watts per candle power. The current consumption is practically constant during the whole life , increasing slightly at first and then falling off.

From the individual candle power curves it will be noticed that the Columbia lamps vary much more than either of the other makes. The Columbia lamps average higher in candle power throughout the test. All the candle power curves follow the same general characteristics; viz., an abrupt increase during the first fifty hours and then a gradual falling off during the remaining life of the lamp. Since the current consumption is approximately constant the efficiency varies almost directly with the candle power and will be seen to be greater for the Columbia lamp.

The lower efficiency of the Kuzel lamp is partly due to the fact that the filament passes through twelve additional loops which cool the filament causing dark spots which decrease the candle power and act as dead resistance in the consumption

of power.

The filament of the Just lamp is drawn tightly over the spiders while those of the other type are mounted losely. The tightened filament is found to vibrate much more under shock. The spring supported spire proves to have too little inertia to warrant its use. The vibration often causes short circuiting of parts of the filament, or even rupture.

The Just and Columbia lamps can generally be repaired by welding, while the Kuzel lamps cannot. This is a decided disadvantage. A repaired lamp usually has greater candle power than before rupture, but on account of the higher temperature caused by the increased current the life is usually short.

It was concluded that in all respects the Columbia lamp, as tested, was greatly superior to either of the other types: the life was longer, the efficiency greater, and the candle power higher.

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MICRO-PHOTOGRAPHS OF TUNGSTEN FILAMENTS. SHOWING NEW FILAMENTS AND THE FILAMENT AFTER 960 HOURS BURNING

NEW JUST FILAMENT.

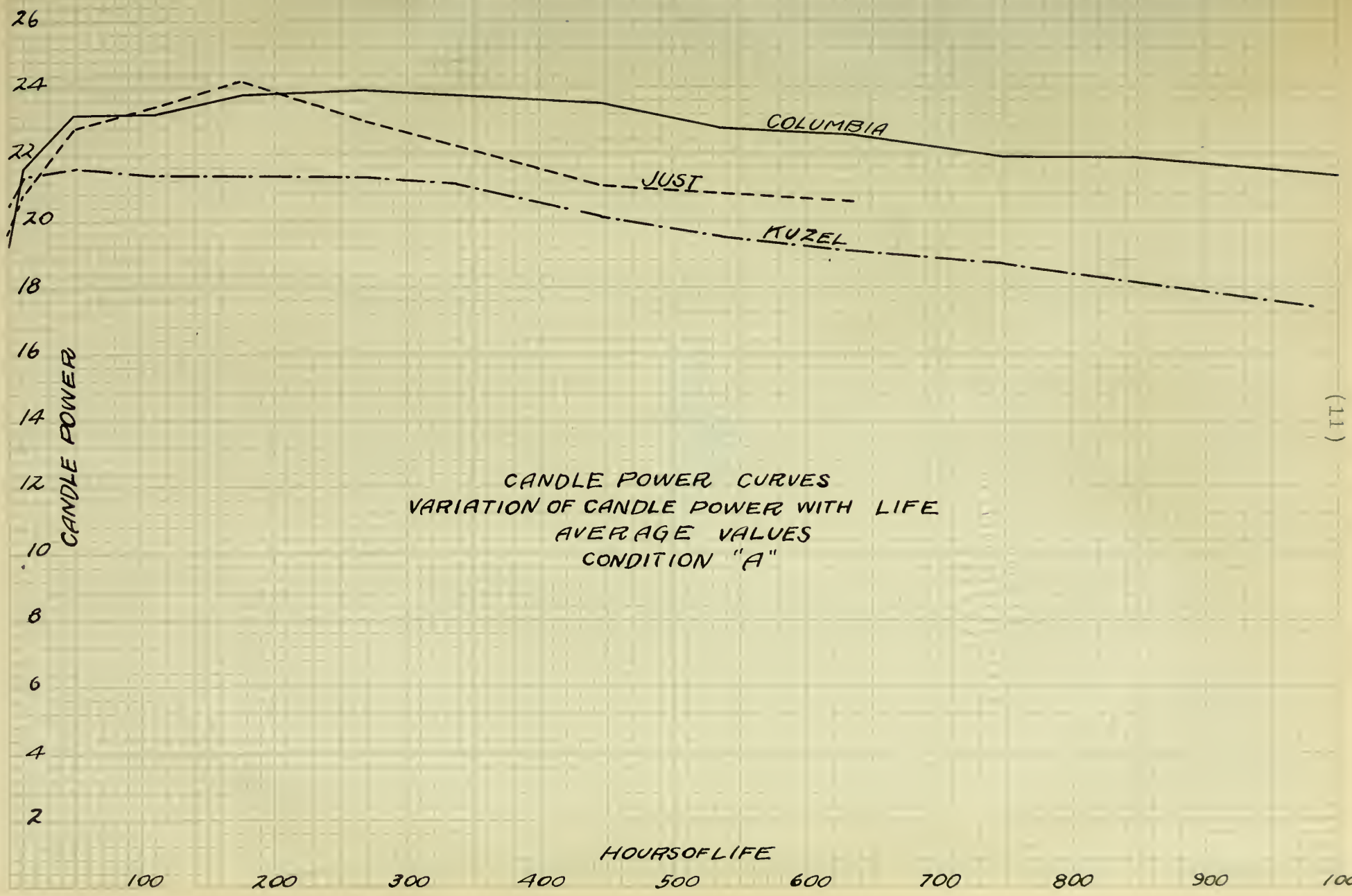
JUST FILAMENT 960 HRS.

NEW COLUMBIA FILAMENT

COLUMBIA FILAMENT 960 HRS.

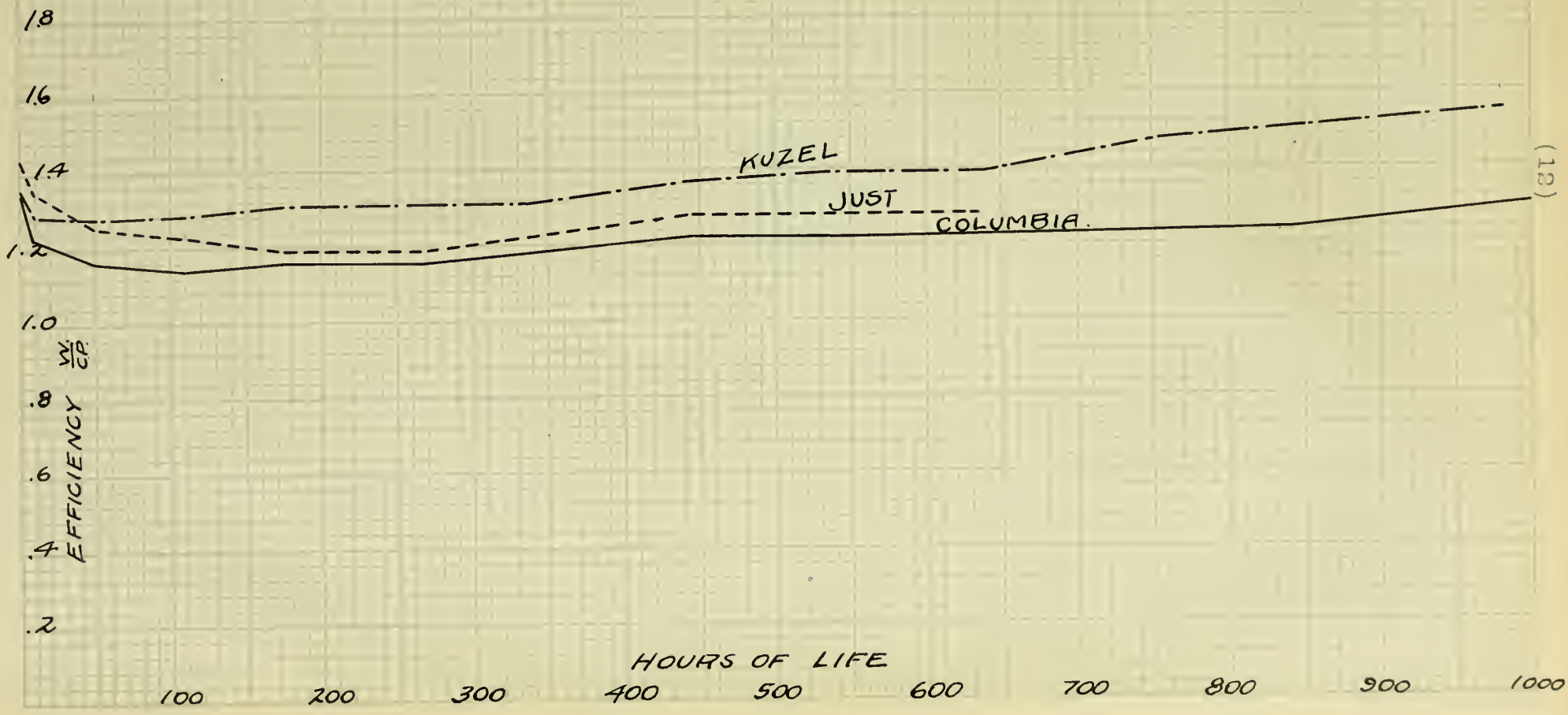
NEW KUZEL FILAMENT.

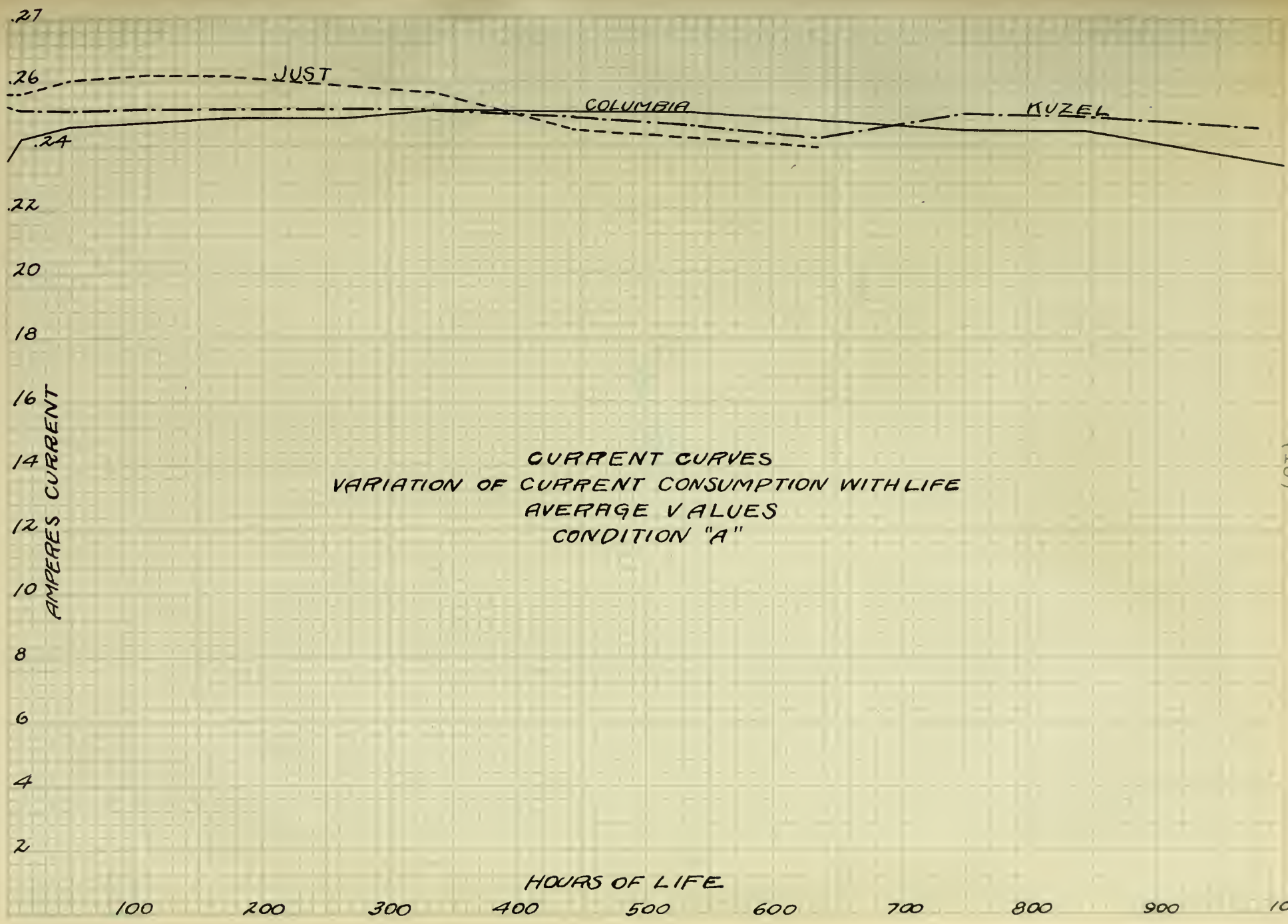
KUZEL FILAMENT 960 HRS



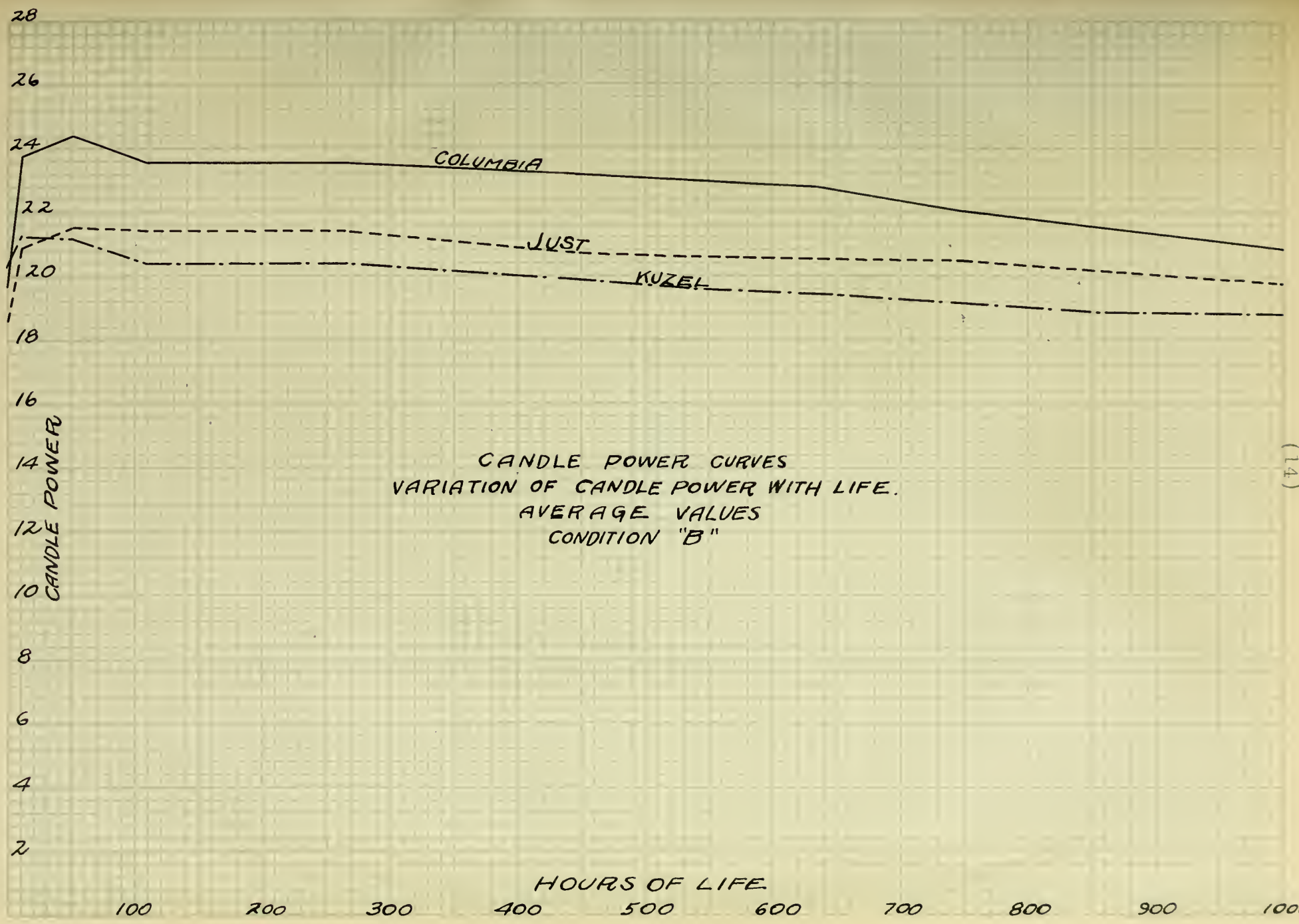
CANDLE POWER CURVES
VARIATION OF CANDLE POWER WITH LIFE
AVERAGE VALUES
CONDITION "A"

EFFICIENCY CURVES
VARIATION OF WATTS PER CANDLE POWER WITH LIFE.
AVERAGE VALUES
CONDITION "A"

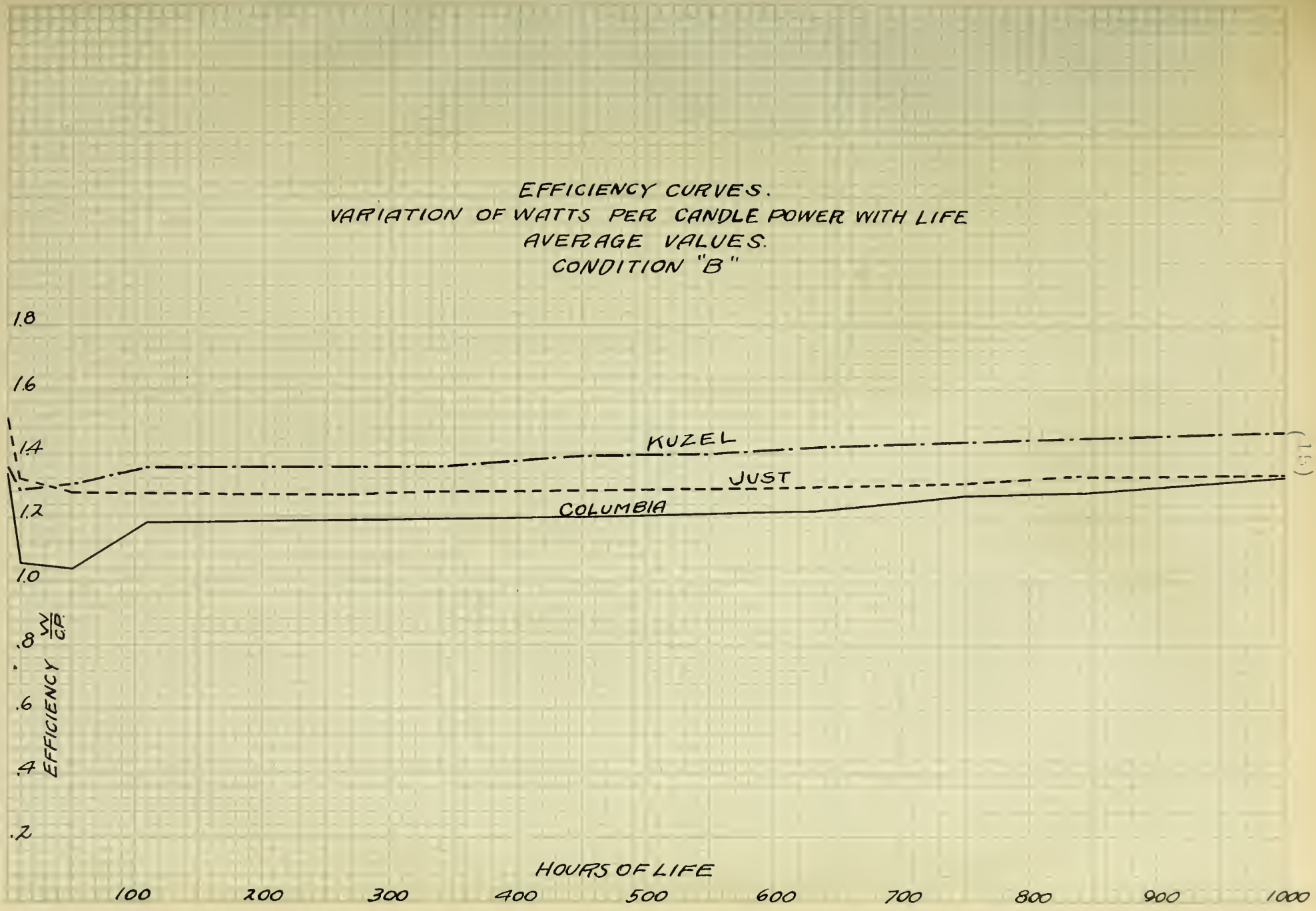




CURRENT CURVES
VARIATION OF CURRENT CONSUMPTION WITH LIFE
AVERAGE VALUES
CONDITION "A"



CANDLE POWER CURVES
VARIATION OF CANDLE POWER WITH LIFE.
AVERAGE VALUES
CONDITION "B"


EFFICIENCY CURVES.
VARIATION OF WATTS PER CANDLE POWER WITH LIFE
AVERAGE VALUES.
CONDITION "B"
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1.6
1.4
1.2
1.0
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EFFICIENCY W/CP
KUZEL
JUST
COLUMBIA
HOURS OF LIFE
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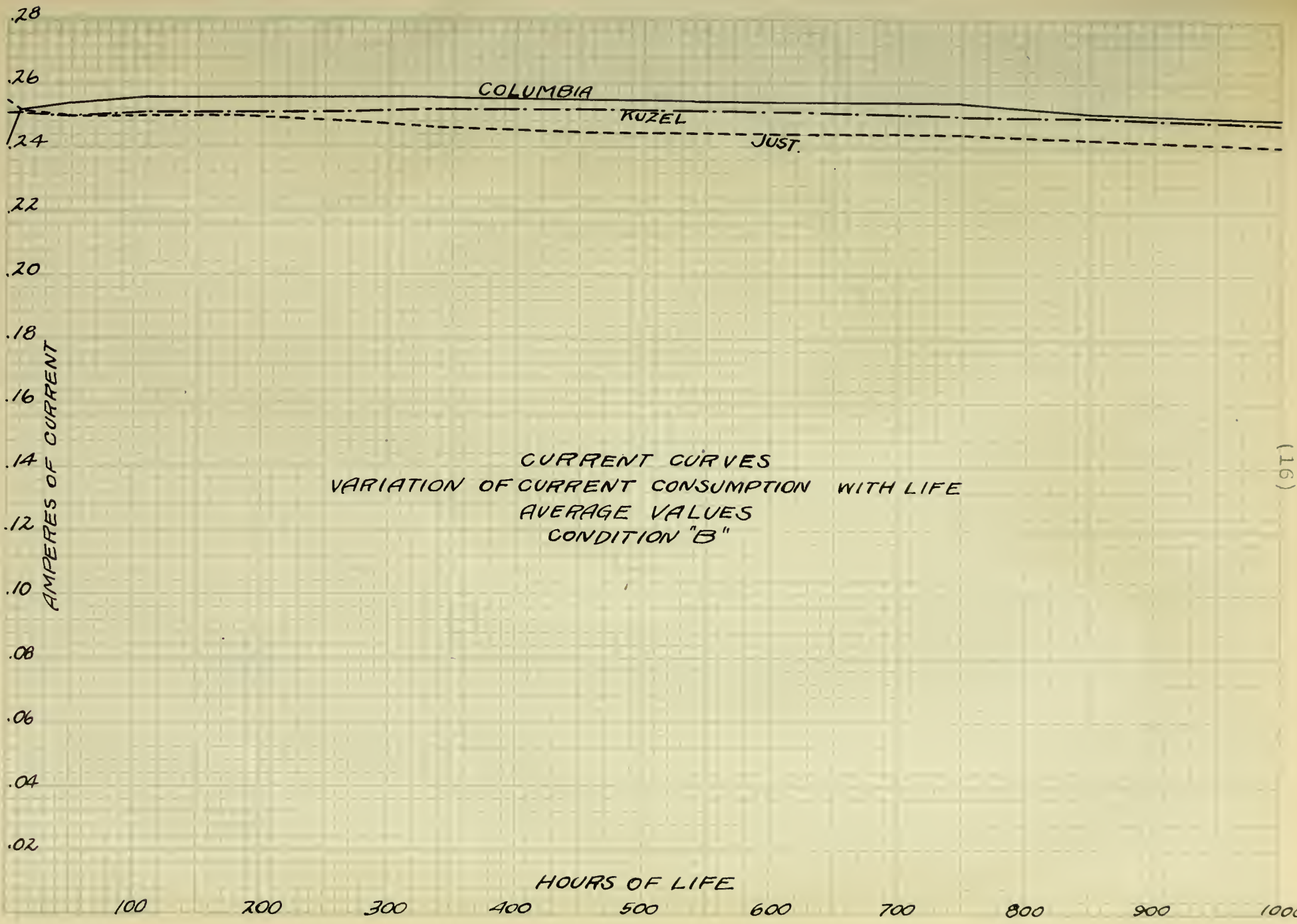
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COLUMBIA
KUZEL
JUST.
AMPERES OF CURRENT
CURRENT CURVES
VARIATION OF CURRENT CONSUMPTION WITH LIFE
AVERAGE VALUES
CONDITION "B"
HOURS OF LIFE
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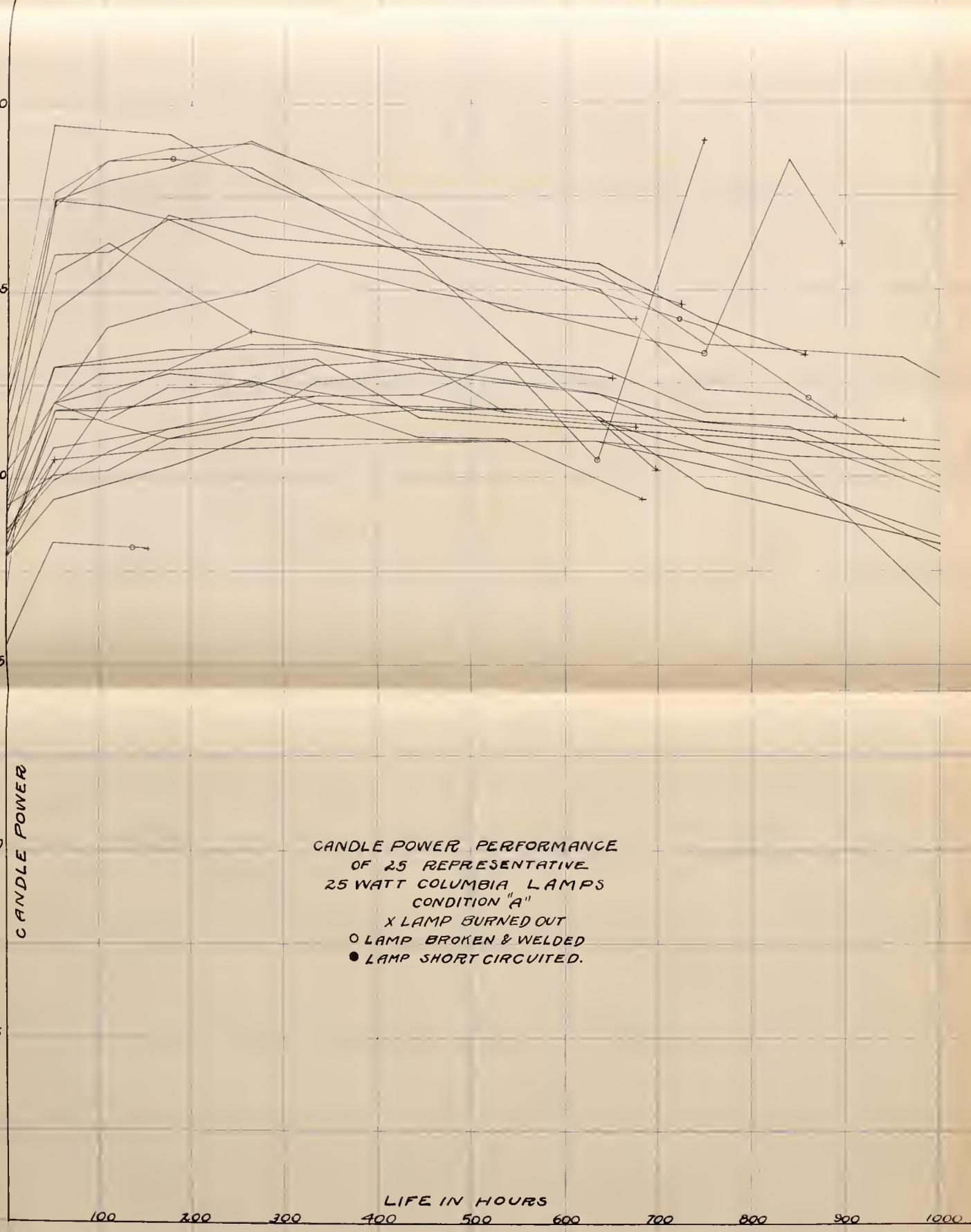
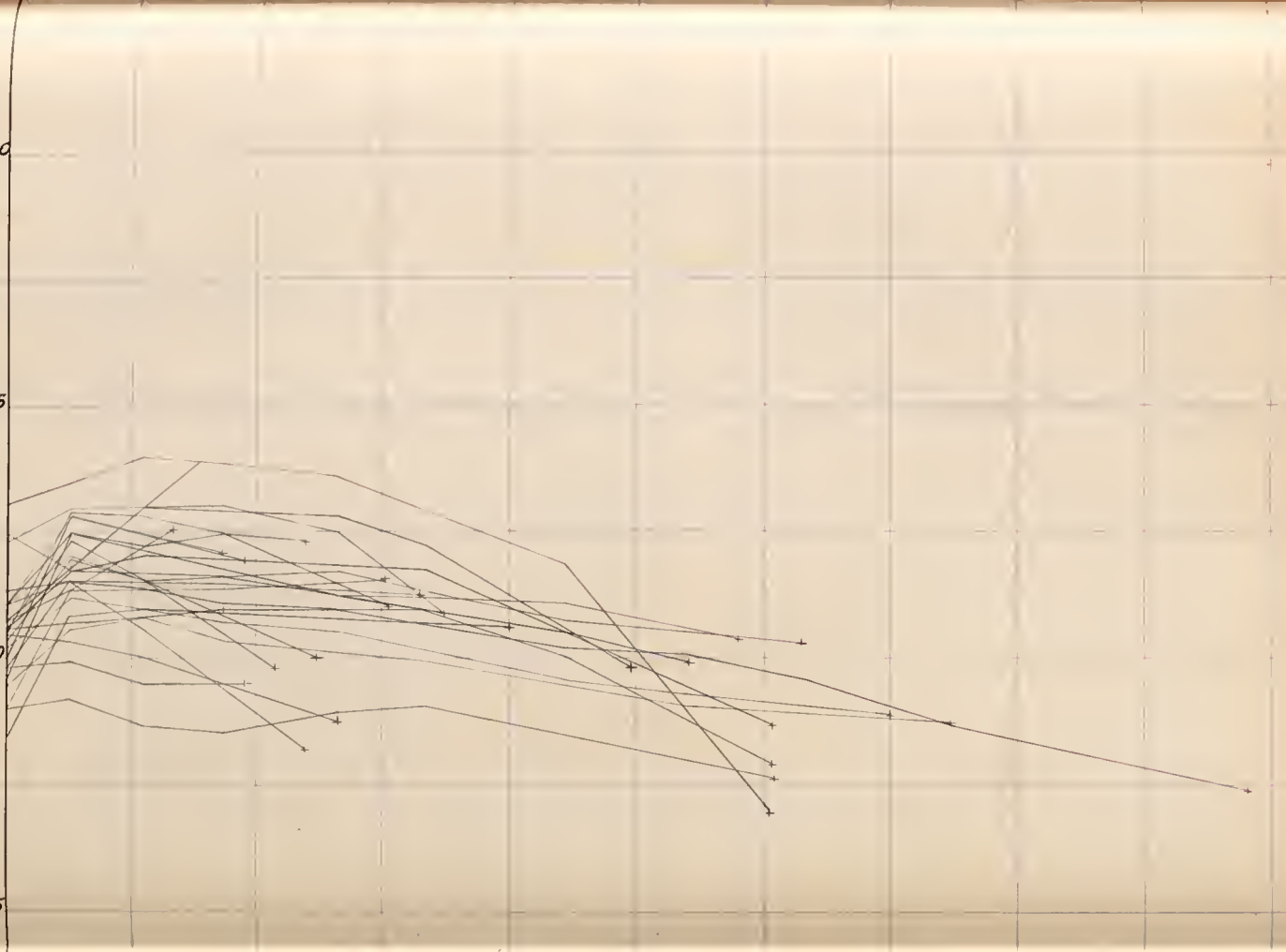


CANDLE POWER PERFORMANCE
OF 25 REPRESENTATIVE
25 WATT COLUMBIA LAMPS
CONDITION "A"
X LAMP BURNED OUT
O LAMP BROKEN & WELDED
● LAMP SHORT CIRCUITED.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CANDLE POWER
CANDLE POWER PERFORMANCE.
OF 25 REPRESENTATIVE
25 WATT KUZEL LAMPS
CONDITION "A"
X LAMP BURNED OUT
O LAMP BROKEN & WELDED
● LAMP SHORT-CIRCUITED
LIFE IN HOURS
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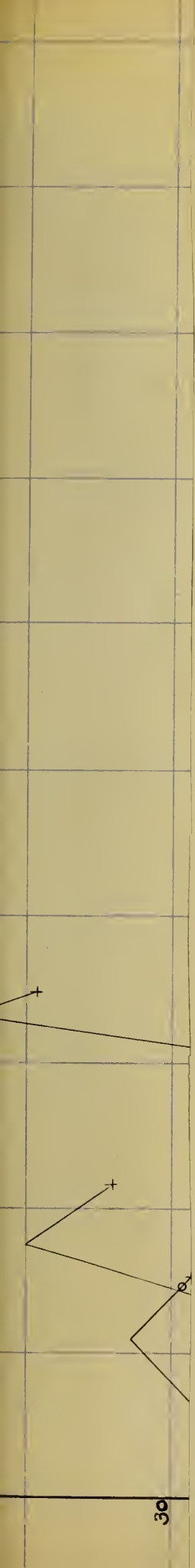
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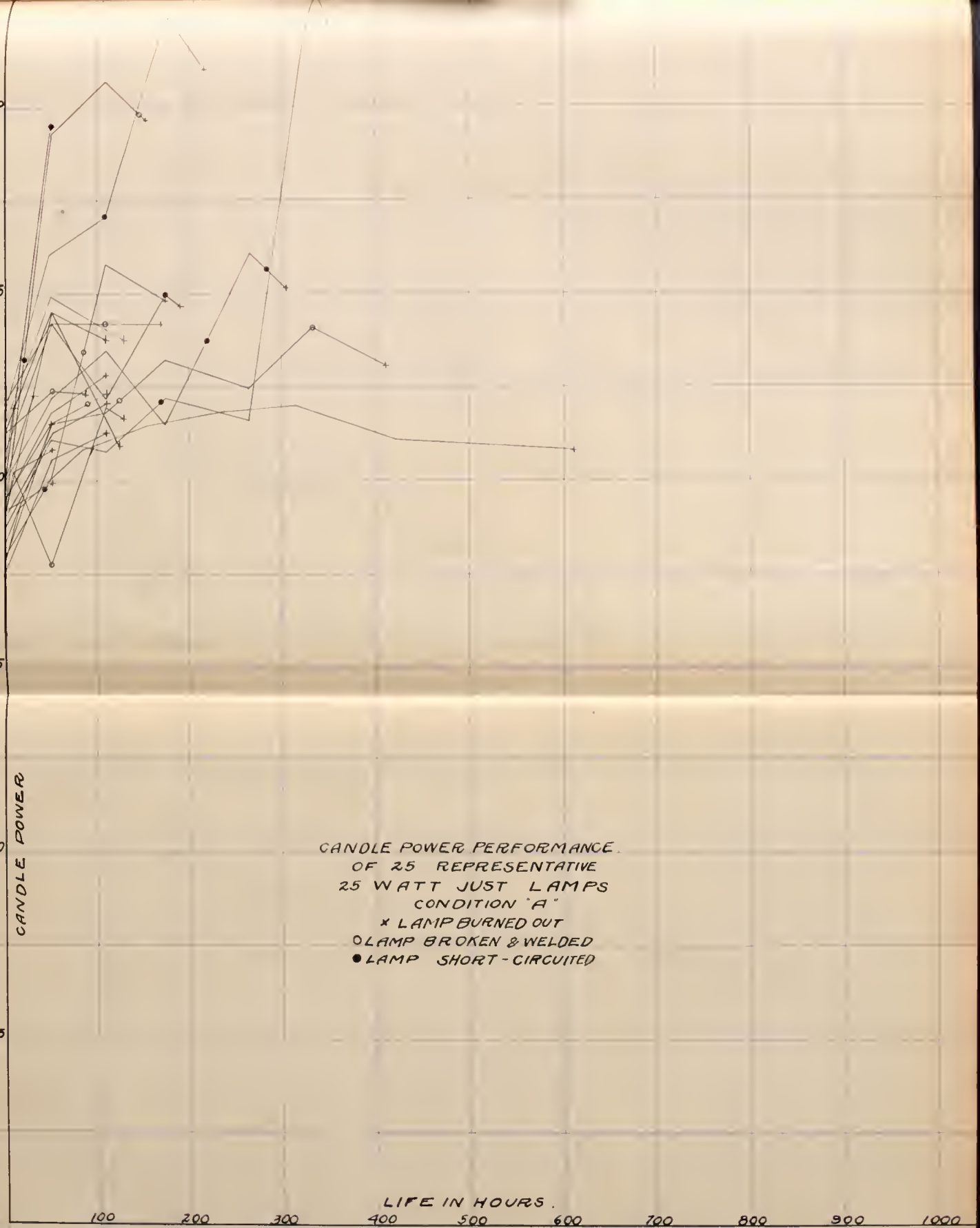
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CANDLE POWER
CANDLE POWER PERFORMANCE
OF 25 REPRESENTATIVE
25 WATT JUST LAMPS
CONDITION "A"
× LAMP BURNED OUT
○ LAMP BROKEN & WELDED
● LAMP SHORT-CIRCUITED
LIFE IN HOURS.
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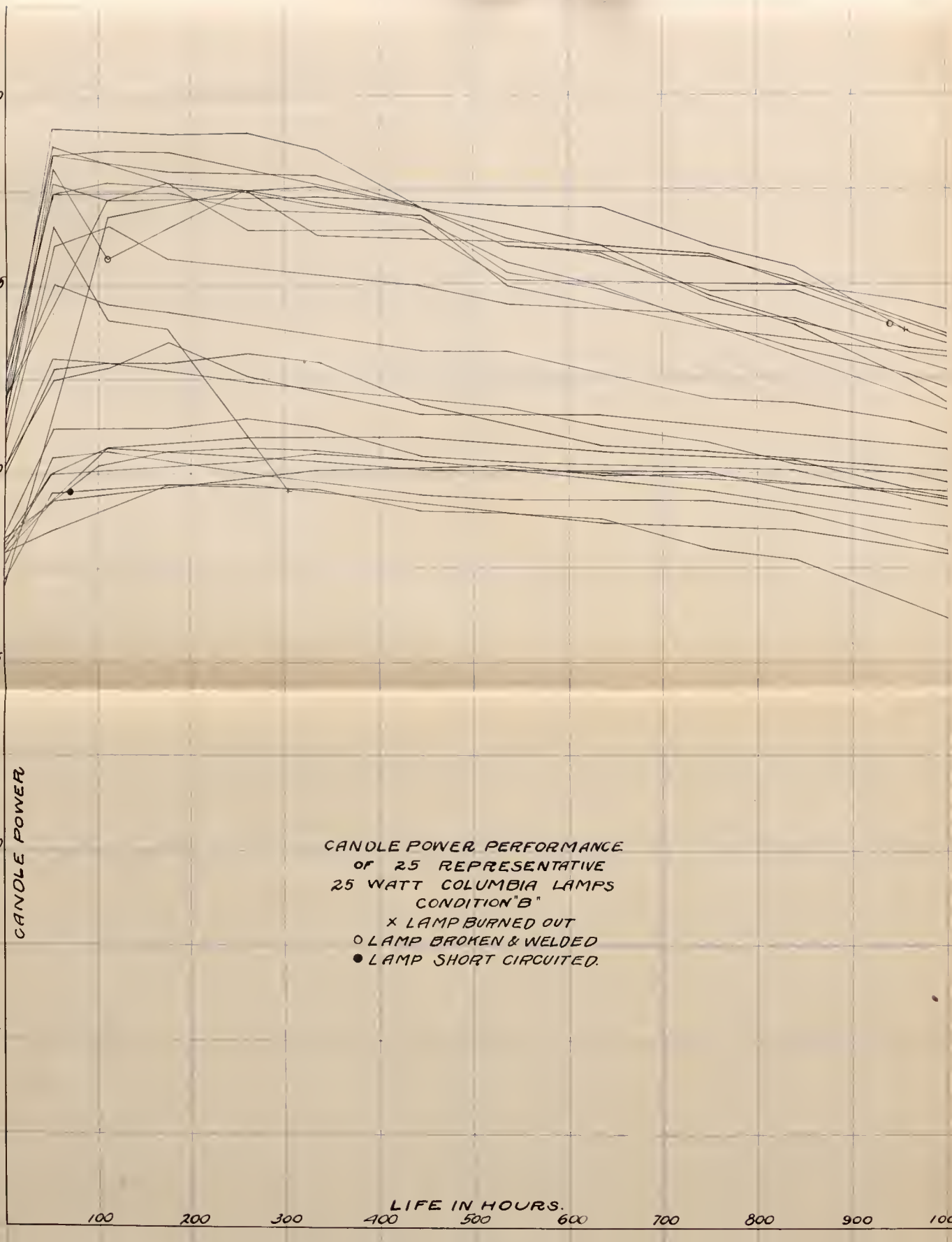
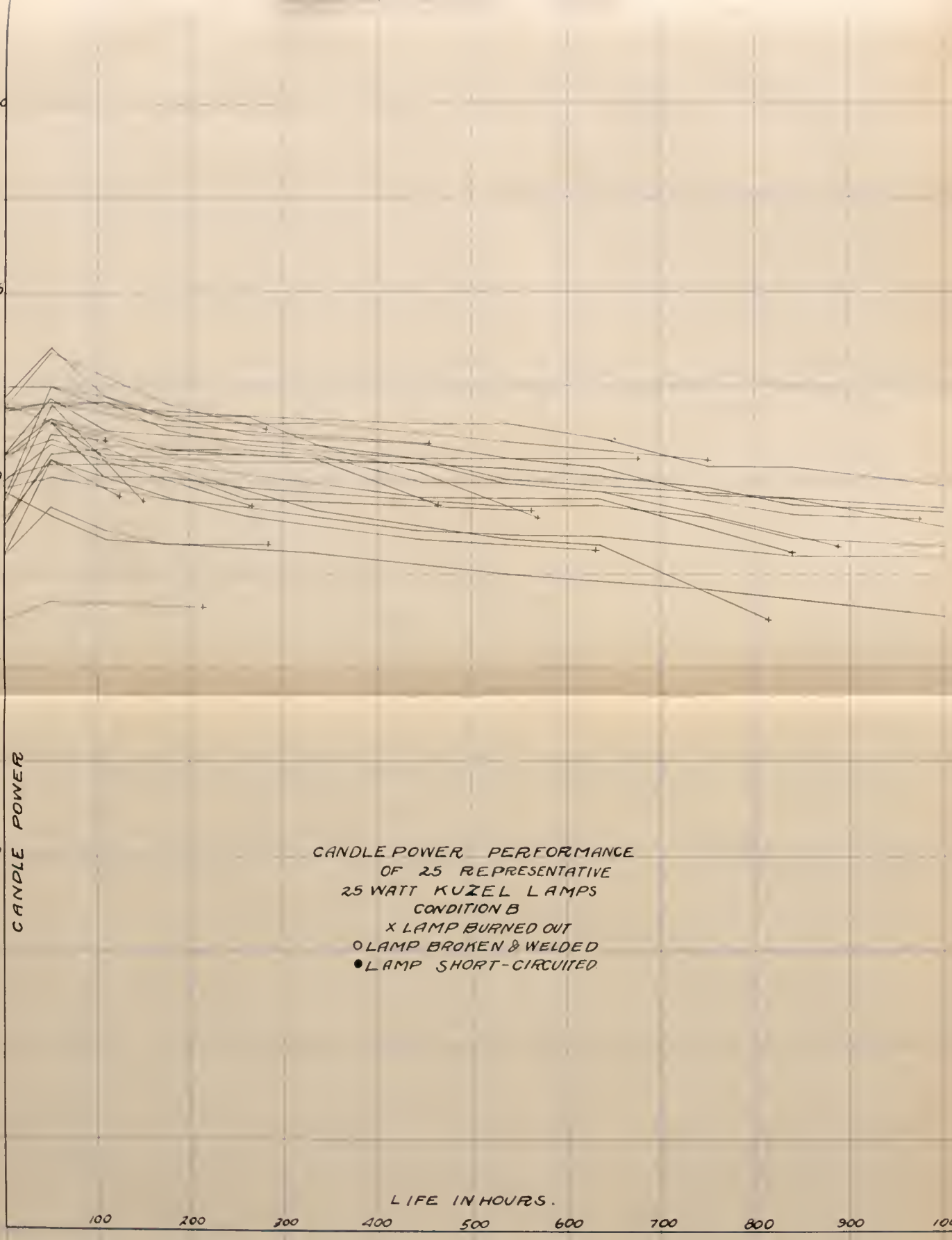


CANDLE POWER PERFORMANCE
OF 25 REPRESENTATIVE
25 WATT COLUMBIA LAMPS
CONDITION "B"
× LAMP BURNED OUT
○ LAMP BROKEN & WELDED
● LAMP SHORT CIRCUITED.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CANDLE POWER
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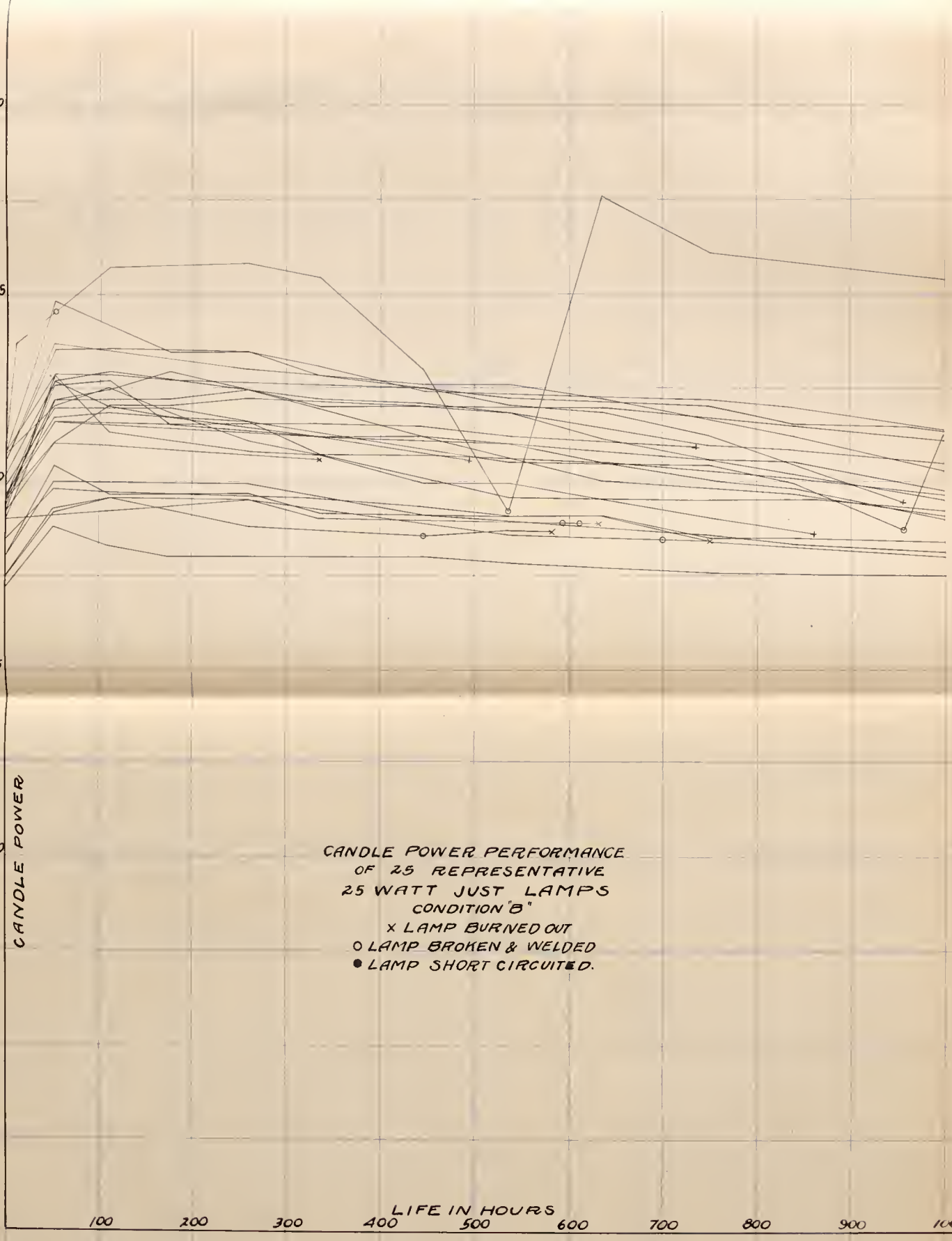
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CANDLE POWER
CANDLE POWER PERFORMANCE
OF 25 REPRESENTATIVE
25 WATT JUST LAMPS
CONDITION "B"
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O LAMP BROKEN & WELDED
● LAMP SHORT CIRCUITED.
LIFE IN HOURS
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